





**University of Al-Mustaqbal**

**College of Science**

**Department of Medical Physics**

**Electricity**

**first stage**

**Electric field, A point charge in an electric field, A dipole in an electric field**

**Lecture Three**

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***Outline***

1. The Electric Field
2. Relationship between Force and Electric Field
3. Electric Field Direction
4. A Point Charge in an Electric Field
5. A Dipole in an Electric Field
6. References
   1. The Electric Field

**Electric field is defined as the electric force per unit charge, is a vector field because.** The direction of the field is taken to be the direction of the force it would exert on a positive test charge.

* The electric force is a field force.
* Field forces can act through space, producing effect even with no physical contact between interacting objects.
* An electric field is said to exist in the region of space around a charged object.
* When another charged object (test charge), enters this electric field, an electric force acts on it.
* The electric field is defined as the electric force on the test charge per unit charge.

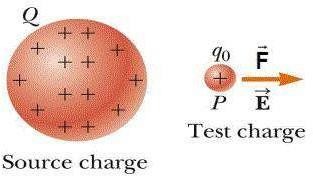
The electric field vector E at a point in space is defined as the electric force F acting on a positive test charge q0 placed at that point divided by the test charge:

The SI units of E are N/C.

Note: that E is the field produced by some charge or charge distribution separate from the test charge; it is not the field produced by the test charge itself.

Also, note that the existence of an electric field is a property of the source charge; the presence of the test charge is not necessary for the field to exist.

* The test charge serves as a detector of the field.



* The direction of E is that of the force on a positive test charge.
* We can also say that an electric field exists at a point if a test charge at that point experiences an electric force.

## Relationship between F and E

Equation 1 can be rearranged as

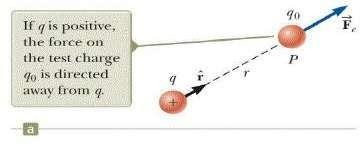


### This equation gives us the force on a charged particle placed in an electric field.

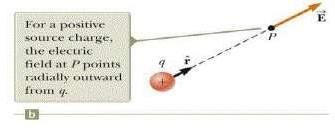
* + - This is valid for a point charge only.
    - For larger objects, the field may vary over the size of the object.
    - If test charge, q0, is positive, the force and the field are in the same direction.
    - If test charge, q0, is negative, the force and the field are in opposite directions.

## Electric Field Direction

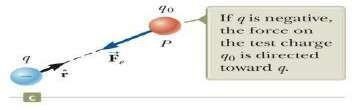
1. If q is positive, then the force on the test charge is directed away from q.

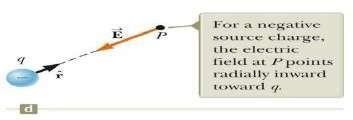


1. The direction of the electric field at P points is also away from the positive source charge.

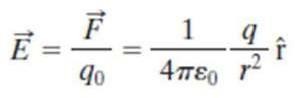
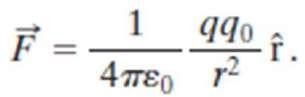


1. If q is negative, then the force on the test charge is directed toward q.



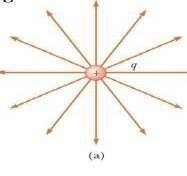
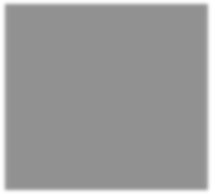
1. The electric field at P points is also toward the negative source charge

Electric Field, Vector Form According to Coulomb’s law, the force exerted by source charge q on the test charge qo, can be expressed as: where rˆ is a unit vector directed from q toward qo. The electric field at P, the position of the test charge is defined by (E = Fe / qo):



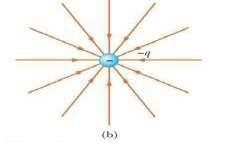
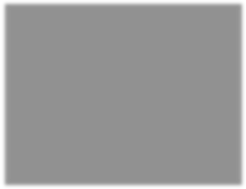
## The electric field lines for a point charge

1. The electric field lines for a Positive Point Charge  The field lines radiate outward in all directions.
   * + In three dimensions, the distribution is spherical.
     + The lines are directed away from the source charge.
     + A positive test charge would be repelled away from the positive source charge.



### The electric field lines for a Negative Point Charge

* + The field lines radiate inward in all directions.
  + In three dimensions, the distribution is spherical.  The lines are directed toward the source charge.
  + A positive test charge would be attracted toward the negative source charge.



## The electric field lines for two point charges (an electric dipole)

### Unlike charges

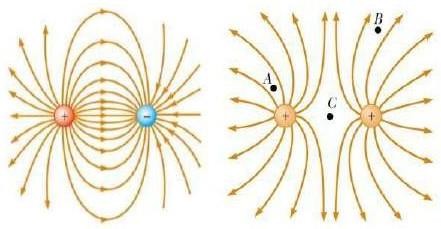
* + The charges are equal and opposite.
  + The number of field lines leaving the positive charge equals the number of lines terminating on the negative charge.

### Like charges

* + The charges are equal and positive.
  + The same number of lines leaves each charge since they are

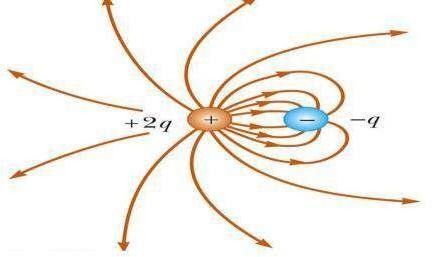
equal in magnitude.

* + At a great distance, the field is approximately equal to that of a single charge of 2q.



### Unequal Charges

* The positive charge is twice the magnitude of the negative charge.
* Two lines leave the positive charge for each line that terminates on the negative charge.
* At a great distance, the field would be approximately the same as that due to a single charge of +q



## A Point Charge in an Electric Field

What happens is that an electrostatic force 𝐹→ acts on the particle, as given by external electrical field 𝐸→→, as given by:



in which q is the charge of the particle (including its sign)

*The electrostatic force* 𝐹→ *acting on a charged particle located in an external electric field* 𝐸→→ *has the direction of* 𝐸→→*, if the charge q of the particle is positive and has the opposite direction if q is negative.*

* 1. **A Dipole in an Electric Field** 1. Electrostatic forces act on the charged ends of the dipole.

1. Because the electric field is uniform, those forces act in opposite directions and with the same magnitude F = qE.
2. The net force on the dipole from the field is zero and the center of mass of the dipole does not move.
3. A dipole experiences a rotating effect.
4. The rotating effect is also called torque on the dipole. We can write the magnitude of the net torque as:

